4/PRTS

Sub B1

Electrostatic holding device

Sub B2

The invention presented here involves an electrostatic holding device specifically designed to hold wafers of conductor or semiconductor materials such as silicon while they undergo micro-manufacturing or any other type of treatment such as plasma treatment in an enclosure under vacuum, for example.

The different treatment operations all throughout the manufacturing process make it necessary to hold the wafer of material solidly on a support. The wafers are generally moved from one station to another by automated mechanisms.

It is known to hold the wafer by flanges supported on the periphery of the upper surface of the wafer, but these systems have the disadvantage of monopolizing a part of the wafer that can not be treated and will thus be lost.

Also known are electrostatic holding systems that use the principle of placing the wafer of semiconductor material on an insulating surface and arranging two electrodes on this surface. The two electrodes are subjected to a difference in potential. The electric field created by these two electrodes thus generates a phenomenon called "electrostatic adhesion".

The treatments or micro manufacturing performed on the wafer make necessary a very large amount of precision, and the wafer must thus be held perfectly throughout the treatment cycle. However, when the semiconductor material that comprises the wafer or

the material that comprises the sole plate is subjected to an electric field of the same polarity for a certain amount of time, it has a tendency to accumulate charges which will keep the wafer adhered to the same surface when the outside electric field is no longer applied.

Sub B3

The US patent 5452177 describes an electrostatic holding device on a circular insulating surface under which are placed at least six electrodes arranged regularly in pairs, opposite each other relative to the center of the circular surface. The electrodes are supplied by an A.C. voltage generator, supplying six different voltages, each pair of electrodes being supplied cyclically at different polarities. The three pairs of electrodes are supplied by signals that are phase-shifted by a phase of 120 degrees in a manner so that two pairs of electrodes are supplied at the moment when the third changes polarity. The commutation frequencies are on the order of 30 Hz.

In order to achieve this result, the system implements mechanisms for supplying the electrodes which are very complex and thus costly, and on the other hand, the use of A.C. voltages induces currents in the wafer that can be harmful when the wafer is equipped with electronic components.

Sub B4

The patent EP 294 556 describes an electrostatic holding system comprised of two electrodes supplied by a D.C. voltage. Between each cycle for holding the object, the electrode polarities are inverted in order to release electrostatic charges. The configuration of the electrodes described in this patent (in the form of alternating lines) is not suitable for optimizing the distribution of the fields in the object. Thus, the pressure of electrostatic adhesion runs the risk of not being uniform over the entire surface of the object. On the other hand, this patent is limited to the presence of two electrodes. It is

thus not possible to invert the polarity during the treatment of the wafer because it would become unstuck at the moment the polarity is inverted. Finally, if the duration of the holding of the object is relatively sizeable, the accumulated electrostatic charges will make it difficult to detach it.

B4 cont'd.

The main problems encountered in electrostatic adhesion lie in successfully simultaneously obtaining a strong adhesion of the object and easily detaching it, and thus in preventing any accumulation of charges while it is held.

The purpose of the invention presented here is to propose a new electrostatic holding device having a simplified constitution that is thus of economic interest, while ensuring a perfect holding of the wafers and in avoiding any accumulation of charges that can restrict the withdrawal of the wafer.

For this purpose, the device is comprised of an electrically insulating surface under which at least two pairs of electrodes are arranged, characterized in that the pairs of electrodes are supplied cyclically at different polarities in a manner so that at any time at least one pair of electrodes holds the wafer.

Another characteristic of the invention lies in the annular shape of the electrodes. Thus, the pressure for holding the wafer is constant over all of its periphery. Due to this fact, the wafer is held at any moment on its periphery, there is no risk of deformation of the wafer when it is subject to a stress at an isolated point on its surface.

According to another characteristic of the invention, the surface of the holding device has geometric variations that make it possible to limit the contact surface between the wafer and the device.

~~Other advantages and characteristics appear in reading the following description of the embodiment forms of the invention given as a non-restrictive example and shown by the attached drawings in which:~~

- ~~Figure 1 shows in a section view and in an overhead view, the diagram of the holding device.~~
- ~~Figure 2A shows another embodiment form of the holding device with four electrodes and Figure 2B shows a variation with eight electrodes.~~
- ~~Figure 3A and 3B shows other possible configurations of the electrodes.~~

~~As can be seen in Figure 1, the holding device is comprised of a soleplate (1) made of electrically insulating material on which the wafer to be held (2) rests in contact with the surface (3). The electrodes (4) and (5) are arranged under this surface (3). According to a particular embodiment mode, the soleplate (1) is comprised of a base plate (22) on which the electrodes (4) and (5) are arranged, then the assembly is covered by a dielectric layer (23). The electrodes (4) and (5) and the dielectric layer (23) can be made by serigraphy of thick films according to techniques known to the professional. The use of the technique of serigraphy of thick films in the case of the dielectric layer (23) makes it possible to easily create geometric variations on the surface of the contact with the wafer. These geometric variations, made up of bumps or contact terminals, for example, make it possible to limit the surface of contact between the wafer and the adhesion device. Thus, it is possible to obtain the optimum surface necessary to hold the wafer well. In fact, when the surface of the contact is very weak, the holding force is not~~

B5 cont'd.

sufficient and when the contact surface is very sizeable, it becomes difficult to rapidly detach the wafer.

The base plate (22) can be made of any type of dielectric material, i.e. it is electrically insulating. According to one particular embodiment mode of the invention, the base plate (22) will be made of virgin alumina. The base plate (22) can also be made of titanium or molybdenum. The dielectric layer (23) covering the electrodes can also be made of any type of dielectric material having a ceramic base, for example.

sub B6

The wafer (2) is arranged flat on the surface (3). According to an embodiment mode of the invention, the electrodes (4) and (5) have an annular shape and are arranged on the surface (3) in parallel to the wafer. In this configuration, the electrodes have concentric rings of different diameters whose center corresponds to the center of the soleplate (1). The annular shape of the electrodes is preferred since the soleplate (3) is generally of a circular shape, which makes it possible to hold it over its entire periphery. However, in order to hold the rectangular pieces, for example, the electrodes could be devices in the corresponding shape. The wafer (2) must be arranged on the surface (3) in a manner so that its center corresponds to the center of the rings of the electrodes. In order to obtain a good distribution of the electric field, the planar surfaces of the rings forming the electrodes have the same area. The central electrode (5) can be made in the form of a ring and a disc. The electrodes (4) and (5) are subject to a voltage difference by the intermediary of the power supply (6) that supplies a D.C. voltage of 1000 volts, for example. The field lines created between the wafer and the two electrodes allow the electrostatic adhesion of the wafer (2) on the surface (3). The adhesion pressure is proportional to the square of the voltage difference between the two electrodes.

When they are subjected to an intense electric field, the materials that constitute the soleplate (1) and the wafer (2) have a tendency to accumulate electrostatic charges which runs the risk of disturbing the detachment of the wafer even when the electrodes are no longer supplied with power. This accumulation of electrostatic charges is proportional to the time in which the device is supplied as well as the value of the voltage.

The wafer resting on the surface (3) is generally raised by rods (20) distributed on its surface in order to then be grasped by a manipulator arm. The rods translate vertically in holes (21) that go through the soleplate (1) under the action of an actuator, for example. One thus imagines very well that the rods would damage the wafer if the wafer stayed adhered to the surface (3).

Sub B7

~~In the case of a device that consists of two electrodes and for the processes that require a relatively short holding time, for which the wafer (2) does not have the time to become charged, the solution consists in inverting the polarities of the two electrodes between each change of the wafer. Thus, the charges accumulated by the soleplate (1) can drain off. For this purpose, the power supply is provided with a known type of automatic system for changing the polarity, for example, synchronized with the manufacturing or treatment cycle, at each end of the cycle, for example, the polarities are inverted.~~

For treatment times that are longer or require a greater adhesion pressure, the present invention proposes using several pairs of electrodes supplied cyclically at different polarities in a manner so that at any moment at least one pair of electrodes holds the piece. According to a possible embodiment mode of the invention presented in

Figure 2A, the electrodes are made in the form of four concentric rings (7), (8), (9), and (10) functioning in pairs. The power supply is provided for this purpose with a system for polarization and supplying power to the electrodes cyclically. The cycle of power supply and polarization of the electrodes can be the following, for example.

From t0 to t1, the electrode (7) is supplied positively and the electrode (9) is supplied negatively.

From t1 to t2, the electrode (7) is supplied positively, the electrode (9) is supplied negatively and the electrode (8) is supplied positively and the electrode (10) is supplied negatively.

At t2, the electrodes (7) and (9) no longer need to be supplied with power since the electrodes (8) and (10) have taken over the relay.

From t2 to t3, the electrode (8) is supplied positively, and the electrode (10) is supplied negatively.

From t3 to t4, the electrode (8) is supplied positively, the electrode (10) is supplied negatively and the electrodes (7) and (9) are re-supplied, but at different polarities which allows the charges to drain off.

From t4 to t5, the electrode (7) is supplied negatively, and the electrode (9) is supplied positively.

The cycle thus continues during the entire treatment or manufacturing phase of the wafer.

The pairs of electrodes designated above are only one example to illustrate the functioning of the device, one could just as well imagine the electrodes (7) and (10) functioning together or any other possible combination.

According to another embodiment mode shown in Figure 2B, each electrode is split in two, i.e. four pairs of electrodes, in a manner so as to obtain a better distribution of the adhesion pressure. The power supply cycle is the same as above.

According to this principle of inversion of polarities, the soleplate can stay held indefinitely without an accumulation of charges. Moreover, since a sizeable value of voltage no longer risks charging the wafer too rapidly, the adhesion pressures can become much more sizeable.

The commutation time of the electrodes can be variable depending on the supply voltage and depending on the capacity of the wafer to charge. As an example, for a wafer made of silicon held at a voltage of 1000 volts, the optimum commutation time is one minute, or a commutation frequency of 0.016 Hz. It is very obvious that this time is variable and can be reduced to a few seconds or less; however, it is important to prevent an excessive commutation that would damage the components of the power supply. In a general manner, the commutation frequency can be between 0.01 Hz and 1 Hz. The components and the embodiment mode of the power supply (6) do not need to be described in detail since they are perfectly known to the professional. As an example, the commutations can be made by relays controlled by a programmable automaton.

The number of rings that form the electrodes is not absolutely limited to four or eight and their number can be even greater without leaving the frame of the present invention.

The configuration of the electrodes can also be done in numerous other forms presented in the Figures 3A and 3B. The symmetry and the equal areas are points common to all of the possible configurations of the electrodes. In Figure 3A, the

electrodes (15) are disk portions numbering four functioning in pairs opposite each other. The number of portions that form the electrodes is variable depending on the stresses in the soleplate and the desired distribution of adhesive pressures, the electrodes can number four as shown in Figure 3A. For greater pressures, the number of pairs of electrodes can be multiplied as shown in Figure 3B.